Contribution ID: **25** Type: **not specified**

Flares, Coronal Mass Ejections and Solar Energetic Particles: new perspectives with the ESA Solar Orbiter mission

Wednesday 26 April 2023 14:30 (45 minutes)

"Our sun is a magnetic and active star. This has been known since the 17th century from the observations of sunspots at the solar surface. In the 19th century the solar sunspot cycle was discovered as well as the first impacts of disturbances of solar origin on the technology. This is in particular the case of the famous Carrington event on the 1st September 1859 at the Sun which led to the disruption of telegraphs for many hours after the event. Nowadays, our hi-tech world has become more and more vulnerable to disturbances from the Sun, in particular to the eruptive events associated with the release of magnetic energy in the solar atmosphere. Different phenomena related to solar activity can disturb our space environment: the amount of solar flux, in particular the ionizing solar flux impinging on the Earth, the level of geomagnetic activity induced in particular by gigantic coronal mass ejections which may reach the earth after a few days of propagation or the production of energetic particles associated with flares or coronal mass ejections that can reach the Earth' s orbit after a few tens of minutes to hours.

Although a lot of progress has been achieved since the advent of space missions to better understand the origin of solar activity and its impact on the heliosphere, many questions are still unsolved. The ESA Solar Orbiter mission was launched in February 2020 to provide unprecedented observations of our star's surface, atmosphere and environment. I will present the main objectives of this new mission and of its 10 instruments designed to combine remote sensing observations of the solar atmosphere with in-situ measurements of the parameters of the ambient plasma. I will show some of the first observations of the mission and will then focus on the topic of particle acceleration in solar flares and transport from the solar corona towards the heliosphere. Energetic particles play indeed a major role in the active Sun because they contain a large amount of the magnetic energy released during flares. Energetic electrons and ions interact with the solar atmosphere and produce high-energy X-rays and γ-rays. Energetic particles can also escape to the corona and interplanetary medium, produce radio emissions (electrons) and may eventually reach the Earth's orbit. It is currently admitted that solar flares are powered by magnetic energy previously stored in the coronal magnetic field and that magnetic energy release is likely to occur on coronal currents sheets along regions of strong gradient of magnetic connectivity. I will review our current understanding of particle acceleration and transport in solar flares and show first results on this topics obtained with Solar Orbiter X-ray and radio observations from the STIX and RPW instruments.
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Author: Dr VILMER, Nicole (LESIA-PSL Research University, Paris Observatory, Paris, France)

Presenter: Dr VILMER, Nicole (LESIA-PSL Research University, Paris Observatory, Paris, France)

Session Classification: Solar physics and heliosphere